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Effects of gender and social class on dyscalculia among Grade Six pupils in Harare

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Abstract

The study investigated the effects of gender and social class on grade six pupils with above average IQ but with significant deficits in Mathematics performance (dyscalculia). Ten to twelve year old pupils (N = 60) with dyscalculia and a normally achieving (NA) comparison group (N = 68) of pupils of above average performance in Mathematics were administered the Wide Range Achievement Test-Revised (1984) Level I Arithmetic Subtest. Significant gender differences in achievement which favoured males were observed in the criterion group, but not in the comparison group. No significant social class differences in the performance of pupils with dyscalculia were found. Social class was found to have a significant effect on mathematics achievement in the NA group. Results favoured the high social class. The demographic variables of gender and social class thus tend to have some important implications for mathematics education.

Introduction

Defects in learning numerical dexterities are usually referred to as developmental dyscalculia or simply dyscalculia (Ferro & Botelho, 1980; cited in Rosselli & Ardila, 1997). According to the DSM-IV (American Psychiatric Association, 1994), this mathematics disorder is diagnosed when an individual receives significantly lower scores on standardised calculation tests or on numerical reasoning. These difficulties are found to be below what they should be for the age, educational level, and intellectual capability of the individual. A range of deficits or difficulties in working with numbers has been noted in children with developmental dyscalculia, and these include difficulties in reading and writing of numbers, verbalisation of numbers and mathematical procedures, understanding basic mathematical symbols, concepts and operations, and "carrying over" when performing arithmetic operations (Kosc, 1970, cited in Rosselli & Ardila, 1997). From this it would appear that it may be common to find dyscalculia associated with dyslexia.

The concept of dyscalculia in the context of this study was explored with specific reference to the demographic factors of gender and social class in pupils on the criteria of above average IQ, but with no known forms of brain damage, and with no sensory or neurological deficits. The occurrence of developmental dyscalculia and how it relates to gender and social class in the light of the above factors is a current problem in mathematics education. In California, Owen (1971), cited in Bruner, Cole,

and Lloyd (1978), studied the demographic characteristics of age, sex, and social class of both learning disabled children and those in the normal comparison group. Owen's (1971) sample of children fell in the five to fifteen age group and had been identified as in need of remedial education. This research is, therefore, a quasi-replication of the Owen (1971) study seeking to investigate (a) gender differences in mathematics achievement of pupils with dyscalculia and, (b) the effects of social class on the mathematics performance of pupils with learning disabilities.

Significance of the study

From this author's experiences as a school mathematics teacher, a study which seeks to investigate dyscalculia is relevant and significant. Firstly, the relatively high failure rate in mathematics in schools and in public examinations mathematics is useful in learning other subjects, in the solution of daily problems, and in national economic development; justify research targeted at the understanding and improvement of mathematics education. According to the Zimbabwean Ministry of Education, Sports and Culture (1998) the Grade Seven examinations revealed a low pass rate of slightly under 30% in mathematics. Secondly, both schools and parents apparently need to be aware of some of the potential causes of low achievement in mathematics. Psychologically, failure is unhealthy because it may induce anxiety and stress in the pupil and/ or in the parent(s). Consequences of low achievement-related problems may include low self-concept, behaviour problems like inattention, emotional outbursts and truancy. Another factor justifying the study is the apparent inadequate attention which dyscalculia in children with normal IQ and of above average performance in other subject areas has received as compared to reading, writing and spelling (Gearheart, 1986). Lastly, a greater insight into mathematics learning disabilities may help educational policy makers in decisions concerning issues like curriculum design and the production of teaching and learning materials with a view to quality improvement. Most studies on mathematics achievement especially in Zimbabwe have mainly concentrated on normally achieving (NA) children, ignoring the mathematics learning disabled.

Heward and Orlansky (1992) suggest that in almost every case of a child's learning disability, the exact cause is unknown, however, their categorisation of causes concurs with that by French, Ellsworth, and Amoruso (1995) who classify the contributing causes of learning disabilities into intrinsic (neurological) and extrinsic (environmental) factors. Intrinsic factors include the neuropsychological processes which occur in the brain and are important for information processing. Lerner (1993) cited in French, et al (1995) observes that neuropsychological factors (which are

intrinsic) affecting learning are also related to developmental factors (which are extrinsic). It would, therefore, appear that some of the intrinsic and extrinsic factors are interrelated. The term environmental factors is usually interpreted to include the child's total environment, for example, the effect of the home environment including factors like socio-economic status (Morrison & Heinshaw, 1998) and parents' education (Melekian, 1990) both cited in French et al (1995). Pioneer work on arithmetic disorders was done by Luria (undated), a Russian neuropsychologist (Bruner, Cole & Lloyd 1978,).

Usually, the general intellectual capability of children with dyscalculia is normal, with the prevalence rate estimated at six per cent of school age children in the United States (Rosselli & Ardila, 1997). Similar studies have not been carried out in Zimbabwe. According to Judd and Bilsky (1989) other authorities who have provided specific educational suggestions in mathematics without emphasis on low IQ or mental retardation include Cruickshank et al (1961), Johnson and Myklebust (1967), Stanley and Johnson, (1979), Reinsman and Kauffman, (1980), and Bley and Thorton, (1981). In mathematics education, Skemp (1982), Mayer (1989), and Schifter (1996), provided a rich theoretical base on the structure and use of the number schema, which is central to the learning of mathematics.

Gender differences in mathematics performance

Results of several studies on gender differences in mathematics ability suggest that simple generalisations about the superiority of either gender are impossible (Geary, 1994). The size and direction of gender differences depend on a number of factors (Bridgeman & Wendler, 1991; Hyde, Fennema & Lamon, 1990). A comprehensive review by Hyde et al (1990) indicated that age, type of task, e.g., computation of problem solving and selectivity of the sample, all appear to be important determinants of gender differences in mathematics achievement. In a longitudinal study with a sample of 7 000 children, Marshall and Smith (1987) cited in Geary (1994) found that girls had an advantage over boys on basic arithmetic tests from grade three to six. They suggest that the advantage appears to be primarily related to skills in solving complex arithmetic problems. Lummis and Stevenson (1990) suggest that differences between elementary school boys and girls which favour boys might be related to intra-individual comparisons. Girls tend to prefer reading to mathematics, whereas boys tend to prefer mathematics to reading. Gordon (1995) cited in the Ministry of Education, Sport and Culture (1998) found that girls were seriously disadvantaged attitudinally compared to boys when it came to the learning of mathematics.

Gross-Tsur, Manor and Shalev (1996) evaluated the prevalence and demographic features of 11 – 12 year old children with dyscalculia. The results indicated that unlike other learning disabilities like dyslexia, developmental dyscalculia affects both sexes equally. Findings by Serbian and Connor (1979), Crystal and Stevenson (1991), and Lynn and Hyde (1989) all cited in Geary (1994) point to the importance of family factors in nurturing experiences and behaviours that enhance the development of mathematical competencies in children. Although the creation of conducive environments may be a result of gender sensitivity, it may also be a function of the family's social status and some racial practices. Serbian and Connor (1979) cited in Geary (1994) maintain that children's engagement in behaviours that provide spatial-related experiences (for example building with blocks or playing with construction toys) helps to develop mathematical concepts. It would appear that these factors largely tend to be functions of the family's social class, with higher-class families more likely to present their children with positive factors.

Rust and Golombok (1989) introduce a political element by the assertion that when different sub-groups (social classes) hold differing relations to the power structure (mainly economic power), it is the dominant group which defines the parameters by which things are to be judged, including the school curriculum. They maintain that it is generally members of the group that define the standards and who performs higher on those standards. This scenario relates to the class and power structures in terms of factors like the availability of resources and the motivating factors for achievement. The above may be taken as a strong argument against claims by Jensen (1969) cited in Rust and Golombok (1989) that racial mean IQ differences remain even when socio-economic factors were taken into account. Zindi (1994) and Rust and Golombok (1989) in review of this issue appear to share the same view in opposition to Jensen's (1969) notion that lower class and black children in particular, exhibit general weaknesses in abstract thinking representing a deficit. They maintain that an adjustment for cultural or racial differences is not a simple matter and that it is implausible that the complex interaction effects can be adjusted for by any simple covariance analysis.

The UNCTAD (1997) classified Zimbabwe as a "highly unequal society" (Raftopoulos, Hawkins, & Amanor-Wilks, 1998). The poorest who form about 40% of the nation share only 10% of the national income compared to the richest 20% who get 60% of the wealth. The report further highlights that in education, the existing system provides relatively fewer resources to children from poor families at all levels. According to the Human Development Index (HDI) figures for 1998, Harare was ranked first with an HDI of 0.79 as compared to the national index of 0.72. Although

gender stereotypes especially in the rural areas and among the poor urban families, may affect children's thinking and after school activities, it would appear that the greatest single determining factor in Zimbabwe is poverty which limits the quantity and quality of food, living space, provision of appropriate learning materials and time. In urban areas like Harare, children from low class families are after school often engaged in several activities to supplement family incomes.

The Zimbabwe Ministry of Education, Sport and Culture (1998) identified some of the home and school factors that show a gender bias against girls, which negatively affect school achievement. These include overloading girl children with household chores and discriminatory access to resources and activities. All the above negative factors may have a strong bearing on developmental dyscalculia. This study explores (a) the gender differences in mathematics achievement of pupils with dyscalculia and (b) the effects of social class on the mathematics performance of pupils with learning disabilities.

Methodology

The study used a 2 (gender) x3 (social class) ex-post-facto criterion group design. It was deemed to be the most appropriate design for the study because instead of creating treatments, it examines the effects of naturalistically occurring treatments (i.e., the independent variables of gender and social class) on the already existing outcome (criterion), which is the condition – dyscalculia. Ex-post-facto refers to the attempt to relate the after-the fact treatment to an outcome; Tuckman (1988) maintains that this design has advantages over experimental treatments in that the criterion group's characteristics are already defined (known) and there is no attempt to manipulate the independent variables. This tends to increase internal validity. The other advantage is that it guards against errors in random sampling. However, the disadvantage of this design in the study was that some of the variables inherent in the criterion group (e.g., IQ levels) were difficult to control.

Study participants

The study drew participants from a population of grade six pupils in the formal school system in the Harare Region of Education. Pupils in the 10 – 12 year age range were considered. Participants in both the criterion and control groups had to fit in the criteria of above average IQ, with no sensory or neurological deficits, and with no known forms of brain damage. Pupils in the criterion group had identified learning disabilities in mathematics.

Participants were drawn from a sample of 22 primary schools (11,2%) out of a total of approximately 198 in the region. The cross section of schools included all types in order to cater for all social classes. The sample consisted of two main groups, the criterion group ($N = 60$) with 30 pupils in each of the sub-groups balanced for gender and for race, black and non black. Twenty pupils fitted into the three social classes, low, medium, and high. All the six cell frequencies of the 2 (gender) \times 3 (social class) design were equal with ten pupils. A comparison group of ($N = 68$) participants, but with unequal cell frequencies was used.

Grade six was targeted as the appropriate educational level because dyscalculia, when associated with normal or high IQ and not found in association with other learning disabilities, is very rare and may not be apparent until the fifth grade. Earlier than that, children may just be slow and not learning disabled (DSM-IV, 1994). The second reason is that in Zimbabwe, the Schools Psychological Services screens pupils for remediation at the start of grade four. A pupil who fails to benefit from mathematics remediation after grade four and five and continues to function below his or her grade and chronological age levels may have the mathematical disorder (dyscalculia).

Instruments used in the study

A questionnaire was used to collect participants' demographic data, school performance in mathematics and information about family background. Despite problems inherent in scoring, the fill-in response mode was preferred for its major advantages of being less biased and its greater response flexibility (Balian, 1994). This increased accuracy with aspects like the diagnostic algorithms of social class, attitudes, interest and home support.

The Wide Range Achievement Test – Revised (WRAT-R) Level I battery of subtests by Jastak and Wilkinson (1984) was used to determine levels of performance on academic codes of arithmetic reading and spelling. The arithmetic subtest standard scores were used to assign participants into the criterion and comparison groups. On the arithmetic subtest, the items whose units needed conversion to metric units which were used by participants in their syllabus were modified appropriately (e.g., yards and inches to *m* and *cm*. respectively. and pennies to cents). The advantages of the WRAT-R Level I Arithmetic subtest as a basic screening instrument in the study are that firstly, the scores are free from the contaminating effects of comprehension, and hence its results are less confounded by non-arithmetical skills (Jastak & Wilkinson, 1984). Secondly, it has been found to be a valuable tool in

determining learning abilities or disabilities when used in conjunction with a test of general intelligence like the Wechsler Intelligence Scale for Children – Revised (WISC-R). The concepts and skills listed by the arithmetic subtest reveal the types of difficulties (stated elsewhere in the text) observed in children with developmental dyscalculia. Its content validity on standardisation had a high item discrimination index of 0.98 and a person discrimination index of 0.82. The short form of the WISC-R was used to test for IQ in order to control the effects of the variable in the study. The test was administered to participants whose IQ levels were not provided by either the school or parents.

Data collection procedures

The study was carried out in June (Mid-year) to give the participants considerable exposure to the grade six mathematics syllabus. Consent for the participation of schools and pupils was sought by letters from the Regional Directorate, schools and parents respectively. Criterion group participants were initially identified by their schools as having learning disabilities in mathematics only on the basis of scores on teacher made attainment tests and exercises (school assessment) indicated on the questionnaire. Algozine, Christenson and Ysseldyke (1982) cited in Piotrowski and Siegel (1986) found that the single most important factor leading to special education placement was teacher referral; 78% of their referred and tested pupils were found eligible for special education services. School identification was further confirmed by significantly low standard scores on the Wide Range Achievement Test – Revised; Level I Arithmetic Subtest. These were pupils in the low average range of standard scores from 65 – 99. Comparison group participants where those pupils identified by the schools as performing above average in mathematics and also confirmed by their achievement on the WRAT-R1 Arithmetic sub-test (high average range standard scores 100-155).

At each school, all participants were grouped together during the WRAT-R Level I test administration in order to control for the negative psychological effects of isolation and differentiation on performance. The short form of the WISC-R was then administered to 16 of the 157 participants whose IQ levels were not provided on the questionnaire by either the school or parents. The prorating method was used for scoring sums of both verbal and performance scaled scores. Out of the 157 participants 60 were finally assigned to the criterion group and 68 to the comparison group according to the six cells of the design, for final analysis. From the 422 questionnaires that were returned out of the 440 distributed (95% return rate), 128 of the 157 participants tested were assigned to groups having screened and excluded

29 for reasons that included withdrawals, absenteeism or lack of parental consent, identified sensory or mental deficiencies (WISC-R IQ scores lower than 90), and chronological ages above 12 years.

Results

The criterion group (N = 60) with a mean age of 11.4 years and a mean IQ of 96 (average range) had a mean standard score of 85 (low average) and two grade levels below grade 6. Table 1 and Table 2 show that all means for the different sub-groups of gender and social class were found to be in the 80 – 89 range which is low average. The group favours males for gender and the high social class. The same trend was revealed in the comparison group (N = 68) with a mean age of 11.3 years and a mean standard score of 126 (superior range).

Table 1. Arithmetic scores for the criterion and comparison groups

Variables	Criterion Group (N=60)			Comparison Group (N=68)		
	N	M	SD	N	M	SD
1. Gender:						
Male	30	87	8	32	127	15
Female	30	82	9	36	125	14
2. Social Class:						
High	20	86	8	24	134	10
Medium	20	85	10	21	124	16
Low	20	83	9	23	121	14
3. Race:						
Black	30	84	8	33	125	15
Non-Black	30	86	10	35	127	14

In the criterion group, an ANOVA analysis (Table 3) failed to show an additive significant main effect or interactions for gender and social class. However, gender was the only factor that showed a significant effect on the mathematics performance of children with dyscalculia. The significant gender difference at 0.05 significance level was [$F(1;47) = 5, 199; p(0.027) < 0.05$]. The chi-square Mantel Haenszel test for linear association between gender and the dependent variable had an index of 0.03093 which implies a high linear association between the two variables. For the comparison group (N = 68) with unequal cell frequencies for the 2 (gender) x 3 (social class) design, ANOVA produced significant results for the main effects (gender and social class combined) with [$F(4;55) = 3.082; p(0.008) < 0.05$].

Table 2. Criterion group results of analysis of variance by hierarchical approach (n=60)

Source of Variance	Sum of Squares	Df	Mean Square)	F	Sig of F
<u>Covariates</u>	5.150	1	5.150	0.071	0.790
Age	5.150	1	5.150	0.071	0.790
<u>Main Effects</u>	526.416	4	131.604	1.825	0.140
Gender	374.900	1	374.900	5.199*	0.027*
Race	35.330	1	35.330	0.490	0.487
Social Class	119.295	2	59.648	0.827	0.444
<u>2-way Interactions</u>	655.572	5	131.114	1.818	0.128
Gender Race	226.047	1	226.047	3.135	0.083
Gender S. Class	242.736	2	121.368	1.683	0.197
Race S. Class	187.778	2	93.889	1.302	0.282
<u>3-way Interactions</u>	174.572	2	87.286	1.210	0.307
Gender Race S.	174.572	2	87.286	1.210	0.307
Class	1 361.224	12	113.476	1.574	0.133
Explained	3 389.224	47	72.111		
Residual (Error)	4 750.933	59	80.524		
TOTAL					

*p<.05

The single main effect of social class was also significant at $[F(2;55) = 7.232; p(0.002) < 0.05]$. Both variables were also significant at the 0.01 level. This result confirms the assertion by Nie, Hull, Jenkins, Steinbrenner, and Bent (1975) that when using a hierarchical ANOVA approach, if a joint effect is significant, then at least one of the individual effects (factors) should be significant. The significance of social class in the comparison group has some implications for both the home and school environments. Results in Table 3 indicate that participants in the comparison group tended to be significantly affected by all sources of variation combined which showed a significant result $[F(12;55) = 2.460; p(0.012) < 0.05]$.

Table 3. Comparison group results of analysis of variance by hierarchical approach (N=68)

Source of Variance	Sum of Squares	Df	Mean Square)	F	Sig of F
<u>Covariates</u>	48.388	1	48.388	0.287	0.594
Age	48.388	1	48.388	0.287	0.594
<u>Main Effects</u>	2 560.345	4	640.086	3.802*	0.008*
Gender	158.583	1	158.583	0.942	0.336
Race	49.195	1	49.195	0.292	0.591
Social Class	2 435.255	2	1 217.628	7.232	0.002*
<u>Z-Way Interactions</u>	1 785.147	5	357.029	2.121	0.077
Gender Race	593.870	1	593.870	3.527	0.066
Gender Social Class	771.592	2	385.796	2.291	0.111
Race Social Class	431.321	2	215.661	1.281	0.286
<u>3-Way Interactions</u>	576.296	2	288.148	1.711	0.190
Gender Race x Class	576.296	2	288.148	1.711	0.190
Explained	4 970.176	12	414.181	2.460*	0.012*
Residual (Error)	9 260.339	55	168.370		
Total	14 230.515	67	212.396		

*p<0.05

This implies that both independent variables considered in the study for this group has a combined significant effect on mathematics performance. The Mantel-Haenszel test for linear association between performance and the independent variables of gender and a social class had index 0.00147. The 0.00147 index for social class infers exact agreement (linear association) and this confirms the ANOVA results. Overall the results show that there is a significant difference in mathematics performance between males and females with males performing higher.

Discussion

The significant gender difference in mathematics performance which favours males contradicts findings by Bridgeman and Wendler (1991), and Ginsburg and Russell (1981) who found no substantive gender differences in arithmetical skills or conceptual knowledge when they compared elementary school children from the United States with children from two African cultures. In this study, the gender difference which favours males suggests that there are important implications for the ways in which families and schools should create gender equal environments to

enhance the development of mathematical competencies as a function of social status and racial practices. Zimbabwe has already made positive moves towards this direction. The Gender Equity in Education Project (GEEP) whose programmes include holiday coaching programmes for girls in mathematics and science is already in operation. However, more affirmative action towards the learning disabled would be most desirable.

In this study, out of the 31% of the participants who were identified as getting positive home support through parental supervision of homework and getting extra tuition, 20% were males. This confirms studies by Toro, Weissberg, Guare and Liebenstein (1990) found that children with learning disabilities showed a general lack of stimulation (e.g., no parental support and mostly in economic difficulties). This trend may further be explained by factors such as that, home backgrounds classified as supportive mainly had parents with academic qualifications of at least 'O' level and also some tertiary education, with medium to high financial incomes. Medium to high social class parents were found to assist their children with homework, provide them with extra private materials and tuition and expose them to games, toys and other activities which enhance the development of mathematical competencies. The fact that males and high social class participants performed better than females and low social class participants respectively, may be explained by the fact that boys generally favour games, toys and activities which are mathematics related. High social class pupils have the financial resources both at home and at school to foster conducive environments for learning.

Some confounding variables that may have affected results of the study include the type of location of schools which invariably tends to be related to social class, test-wiseness and attitudes. The attitude of participants with dyscalculia as diagnosed by algorithms such as ranking mathematics against other subjects, preferred length of learning time, the nature of games of interest may be a notable factor (uncontrolled independent variable) that affected their performance. Only 27% of the participants diagnosed as having dyscalculia were rated to have a positive attitude to mathematics). Attitude and achievement motivation are important learner characteristics for success. The cause-and-effect debate involving attitude, motivation and perseverance is however, beyond the scope of this study.

Conclusion

The results of this study pose some important implications for the mathematics education of learning disabled children in Zimbabwe, which are of concern to

parents, teachers, the school system, educational psychologists and curriculum developers. There is need for greater family and school involvement in promoting gender equality with regards to the provision of time, learning materials and activities that stimulate and enhance developmental competencies. To address the cognitive and neuropsychological deficits evident in errors common to children with dyscalculia, gender sensitivity in education both at home and at school should be raised through awareness programmes. In school, teaching methods should be clear, concrete, precise and systematic. This implies that remedial programmes for children with dyscalculia should include as much as possible, systematic, concrete verbalisations of the operations and arithmetical procedures (Kosc, 1970 in Rosselli and Ardila, 1997). The school should inform parents of the children with dyscalculia, about the appropriate learning strategies adopted so that the same arithmetic activities may be included in family activities such as shopping, in order to promote the remedial programme.

The involvement of children in tasks that involve detailed descriptions of visual stimuli may help since the pupils usually present with attention and visual-perceptual discrimination difficulties. The use of squared paper to help in the organisation of numbers (e.g., place value in addition and subtraction) may also be of help. The teacher's record of all errors committed by the pupil in order to analyse the cognitive processing steps is also an advisable methodological technique. Overall special education policies are needed so that the materials and human resources needed for the education of learning disabled pupils can adequately be provided for.

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